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NOTES FOR THE OBSERVER

by T. P. Prabhu

1. Variable stars

Sudden appearances of bright 'guest stars' in the sky have been noted from time to time in prehistoric cave paintings as well as in the recorded history of ancient civilizations. While some of these records may refer to comets, some others have been identified with the outbursts of stars in the forms of novae or supernovae. The most spectacular record of a supernova is that in the year 1054 recorded in detail in the Chinese annals and identified later as the one which resulted in the Crab Nebula.

The first recorded discovery of a star varying periodically in brightness is that of ο Ceti eventually named Mira, the wonderful. Mira was seen by Fabricius in 1596, who noted that it was not found in the earlier catalogues or atlases. Bayer saw it in 1603 and designated it as Omicron Ceti. Finally, it was Holwarda in 1638 who noted that the star was visible from time to time, fading to invisibility during the times in between. Beginning with this discovery, the number of stars known for their variability in visual brightness, either in the form of an outburst or as a periodic change, has continuously been rising. Against the 18 stars known at the end of the eighteenth century (Table 1) 700 at the end of the nineteenth, we now know more than 28,000 variable stars. The credit for the discovery of a large number of variables goes to amateur astronomers who also observe a great majority of variable

Table 1. Variable stars discovered between 16th and 18th century, A.D.

Year	Star name	Discoverer	Type
1572	Nova Cassiopeiae	Tycho Brahe	supernova
1600	P Cygni	Blaeuw	nova-like variable
1604	Nova Ophiuchi	Kepler	supernova
1638	ο Ceti	Holwarda	long period variable
1667	β Persei	Montanari	eclipsing variable
1670	CK Vulpeculae	Anthelm	nova
1677	η Carinae	Halley	peculiar variable
1686	χ Cygni	Kirch	long period variable
1704	R Hydrae	Maraldi	long period variable
1782	R Leonis	Koch	long period variable
1782	μ Cephei	W. Herschel	semi-regular variable
1783	WY Satittae	D' Agelet	nova
1784	β Lyrae	Goodricke	eclipsing binary
1784	δ Cephei	Goodricke	Cepheid variable
1784	η Aquilae	Pigott	Cepheid variable
1795	α Herculis	W. Herschel	semi-regular variable
1795	R Scuti	Pigott	irregular variable
1795	R Coronae Borealis	Pigott	eruptive star

stars regularly. The visual magnitude estimates provided by amateur astronomers have been highly useful to the professional astronomers who could not have easily accomplished the task of collecting such enormous data all by themselves. Several associations have been formed to promote the observations of variable stars and also to collect and systematize the estimates made by different observers. The oldest and the most active among these is the American Association of Variable Star Observers (AAVSO). Another active group is the Variable Stars Section of the British Astronomical Association (VSSBAA).

Nomenclature

The familiar Greek designations of the brighter stars are due to Bayer who charted the heavens in 1603. The constellation name that follows the designation is in the genitive form in Latin. Thus β Arietis means the star β of Aries, the ram; γ Velorum means the star γ of Vela, the hull of the boat. Bayer generally gave the designation α to the brightest star in each constellation, β to the next brightest and so on. At times, as in Ursa Major, he preferred the sequence of position in the constellation. After the Greek letters were exhausted, Bayer used the Roman letters in lower case (*a*, *b*, *c*, ...) and thereafter, the Roman letters in upper case (A, B, C, ...). Flamsteed used the Indo-Arabic numerals (1, 2, 3, ...) to designate stars in a given constellation. These designations reach a fainter limit than Bayer's. Flamsteed's designations are generally used these days for the naked eye stars that do not have Bayer's Greek designations, Bayer's Roman designations are used only for a few stars which have held an interest since the historic times, for example *l* Carinae, P Cygni.

Since the times of Bayer and Flamsteed, the boundaries of the original constellations have been revised and were finally standardized by the International Astronomical Union in 1930. Consequently some star names needed a revision too. In such cases the original Greek letter, Roman letter or the Flamsteed number is generally retained, and only the old constellation name is replaced by the new one. For example, when the large southern constellation of Argo Navis was divided into four smaller constellations (Carina, Vela, Pyxis and Puppis), the two brightest stars went to Carina (α Carinae and β Carinae) while the third one went to Vela (γ Velorum). Thus we do not have any star designated α or β in Vela. Another case is that of β Tauri which was shared also by Auriga as γ Aurigae in Bayer's notation. Now we assign this star only to Taurus and consequently there is no γ in Auriga.

When new variable stars were discovered that did not have any previous designations, it was decided to name them in a way that points to their variability. Roman letters in capitals were chosen for this purpose, avoiding the letters of A to Q which were already used by Bayer to name the stars in some constellations. Thus the first newly discovered variable star in each constellation is named R followed by the name of the constellation. Several examples of this appear in Table 1, The variables discovered subsequently were named S, T, ..., Z. Soon the letters were exhausted and the nomenclature was continued to RR, RS, RT, ..., RZ; SS, ST, ..., SZ, and so on until the letter ZZ. Note that the second letter is never earlier than the first one. The star WY Sagittae, known initially as Nova Sagittae (1) was named after it was identified by Weaver in 1950. By this time 46 new variables had been discovered and named in Sagitta. Therefore, this nova has the name of the 47th variable.

The star ZZ would be the 54th new variable in a given constellation. Beyond this, the nomenclature continues through AA, AB, ..., AZ; BA, BB, ..., BZ and so on until QZ. The combinations with the letter J are not used so as to avoid confusion with I. This nomenclature can account for 334 new variables in a given constellation. The new variables found thereafter are named V335, V336 and so on. Thus V335 Ophiuchi is the 335th new variable in Ophiuchus, and is a dwarf Cepheid; V1500 Cygni is the bright nova which exploded in Cygnus in 1975; V4063 Sagittarii is a new variable in Sagittarius discovered in 1978. This is a pulsating star named after its prototype δ Scuti.

Classification

The variations in the stellar energy output show a remarkably wide range due to the different underlying physical causes. The time scales of variations span tens of thousands of years for the secular changes due to stellar evolution at one extreme and millisecond pulses emitted by pulsars at the other. While the evolutionary changes in the life of a single star are not noticeable over the few thousand years of astronomical observations, secular changes have been suspected in several stars since the times of Ptolemy (second century A.D.) who gave us the first estimates of the brightness of the naked-eye stars. The best example is that of Pleione, the seventh star in Pleiades. It has faded by almost two magnitudes since the times of Ptolemy and now hovers close to the limit of naked-eye sensitivity.

Even the variables discovered in the beginning of the modern era (Table 1) contain stars like β Persei that varies regularly with a period of 2.86 days, and the supernovae in Cassiopeia and Ophiuchus for which the observed outbursts are once-in-a-lifetime events. It is, however, possible to classify such diverse types of objects into a few distinct categories. The classification devised in 1938 by Cecilia Payne-Gaposchkin and Sergei Gaposchkin has been very useful in understanding the different mechanisms giving rise to the light variations. The Gaposchkins' classes are the following.

A. *Geometric variables* are the stars which exhibit light variations due to geometrical effects. Such an effect may be caused by the periodic eclipses in a system of two stars rotating about a common centre of gravity. Such stars are known as eclipsing binaries; a typical example is β Persei (Algol). Another type of geometrical variability is seen in an ellipsoidal variable, which has an ellipsoidal shape and therefore presents to the observer different areas at different times as it rotates about its axis. Thus the light emitted towards the direction of earth is modulated with the periodicity of the rotation of the star.

B. The *pulsating* or the *great sequence variables* are the stars which vary in brightness due to intrinsic causes like pulsation. This class includes the long-period variables, semi-regular variables, δ Cephei variables (Cepheids) and irregular variables among others. The term great sequence is used since the different sub-classes of this class can be arranged in a sequence of the periodicity of pulsation which ranges from hours to years.

C. The *cataclysmic variables* include supernovae, novae, recurrent novae and nova-like variables which exhibit outbursts of different degrees, whether only once in their lifetime or more often.

D. The *nebular variables* are the ones involved in nebulosity. The variations in these types of stars are induced generally by their environments and not by any physical change in their interiors.

The causes of the light variations of the pulsating and the cataclysmic variables are *intrinsic* to the stars themselves, while they are *extrinsic* in the case of the geometrical and the nebular variables.

Observing the variable stars

The method of observing a variable star consists of three steps : finding the variable star, estimating its brightness at the time of observation and recording the results as a compilation of the estimates at different instants of time.

A variable star is identified using a finding chart. A naked-eye variable can be identified using any of the star charts available in popular magazines and books on astronomy. As one goes to the fainter objects, one needs to employ binoculars and telescopes and use better finding charts. The AAVSO as well as the VSSBAA provide a set of charts for each variable. Each set consists of a large scale chart of about 10° field and successive charts of smaller scales upto a chart covering a field of a few minutes of arc. The bright stars are identified using the large scale charts and the fainter ones by going to the small scale charts after the brighter stars in the vicinity have been identified as reference stars. The identification requires very little practice since the human brain can very easily identify patterns.

Astronomers use a number termed the star's magnitude to measure the brightness of a star. This concept dates back to Hipparchus (second century B.C.) who divided the naked-eye stars into six classes from the brightest (class 1) to the faintest (class 6) just visible to the eye. A psycho-physical law enunciated by Fechner in 1859 states that a sensation increases in arithmatic progression for a stimulus that increases in geometric progression. The magnitude system in astronomy as well as the decibel system in acoustics are examples of this phenomenon. Thus, equal intervals in magnitude correspond to equal factors in brightness.

John Herschel recognized that the light of a star of the first magnitude is at least 100 times that of a star of the sixth magnitude. N. R. Pogson, subsequently the Director of the Madras Observatory, suggested that the ratio of exactly 100 be adopted, resulting in a factor of $2.512... = 10^{0.4}$ corresponding to one magnitude interval. This factor is adopted today, together with a zero point determined from a standard sequence around the north pole, termed the *north polar sequence.*

An estimate of the magnitude of a star can be made by comparing it with stars of known magnitude. This may be done visually or by using one of the sophisticated techniques like photography or photoelectric photometry. We will concern ourselves here only with the visual estimation.

When the sky is good with no interference from moonlight, stars down to the fourth magnitude are best observed with the naked eye. Stars between the fourth and the eighth magnitude can be observed with binoculars or refractors with apertures of about two inches. A 6-in telescope can show stars up to the thirteenth magnitude. There are plenty of variable stars brighter than this magnitude limit—far more than an individual observer can observe.

An observer who uses binoculars or a telescope should mount the instrument on a stand so that it does not shake during the observations. It is advisable not to use a larger instrument than necessary. While observing a brighter star with a larger telescope, one may cut down the aperture of the telescope with the help of a stop such that the stars fainter than the variable by more than three magnitudes are no longer visible. Also, a higher magnification does not generally aid the observations. The magnification should be such that the variable as well as the comparison stars are in the field of view and as close to the centre of the field as possible.

A difficulty encountered in the visual estimation of magnitudes as also in the accurate photoelectric photometry with high resolution in time is the *scintillation* or twinkling of stars. Scintillations are the rapid fluctuations in the apparent brightness of a star, resulting from the turbulence of the atmosphere within a few kilometres of the earth's surface. Because of the twinkling, the stars may appear to vary in brightness by as much as 10 per cent. However, with a little practice an observer will be able to compare the brightness of two twinkling stars.

There are two major methods of estimating the brightness of the variable stars. The easier of the two is the *fractional method.* This method employs two comparison stars. The magnitudes of the variable and the comparison stars should lie within a range of about one magnitude interval. The magnitude difference between the variable and the comparison star nearest to it in brightness is then estimated in terms of the magnitude difference between the two comparison stars. Typical examples with A and B as comparison stars are : the variable is midway in brightness between A and B; the variable is a quarter interval brighter than B; the variable is a third of the interval fainter than A and so on.

The second method of estimating the magnitude of the variable is the *step* or *grade method.* This method, originally used by William Herschel and further developed by Argelander, is often called Pogson's step method since N. R. Pogson brought it into extensive use. After a few months of practice, this method can yield more accurate results than the fractional method. Observe two stars of nearly equal brightness for a few seconds. Their brightness appears to vary because of scintillations. If one appears brighter as often as the other, they may be assumed to be equal. If one appears brighter oftner than the other, the difference is one step. If one is generally brighter, but sometimes the two appear equally bright, the difference is two steps. If one is always brighter than the other, the difference is three steps or more. One step generally corresponds to about 0.1 magnitudes for an experienced observer. An individual observer should check periodically against the standard stars to fix one's own value of the step.

Red stars present a particular difficulty to the observer due to the *Purkyně effect*, by which a change in red light is estimated by the eye at a higher value than an equal change in blue light. It is therefore better to choose red comparison stars while observing red variables; however, red comparison stars may not always be available since most of the red stars are themselves variable. If the two stars are not of the same colour, an estimate made at a quick glance is superior to the one made after prolonged stares, because the eye adapts for different colours at different rates.

It is important to note the sky conditions prevalent during the observations. The estimates made during poor sky conditions are highly unreliable. Even when the sky is good, the estimates may be poor if the comparison star is far from the variable. This is so because the atmospheric absorption depends on the distance of the star from the zenith. The absorption is the least near the zenith and increases towards the horizon as the secant of the zenith angle. Also, the star appears redder when it is closer to the horizon and is more susceptible to Purkyně effect. Therefore, it is better to observe a variable when it is highest in the sky.

Finally, one need not be discouraged when a star becomes fainter than the limit of one's instrument. If the limit of the instrument is determined well using the standard sequence of comparison stars, the fact that the variable is fainter than this magnitude is also an important piece of information.

We will now introduce five individual variables : two naked-eye Cepheids (δ Cephei and η Aquilae), a long period variable (χ Cygni) that varies from the naked-eye visibility to the limit of an 8-inch telescope, a bright semi-regular variable (μ Cephei) of small amplitude and a nova-like variable (P Cygni) which is almost at a constant brightness since 1715 after more than 100 years of interesting activity. The Cepheids and eclipsing variables repeat their light variations with such a precision that the professional instrumentation is needed to elicit new information on these objects. Cepheids included in this column would thus serve only as an exercise to the beginner. On the other hand, every observation of a long period variable is a new piece of information. It is also important to watch nova-like variables since one cannot predict when these will erupt again.

δ Cephei

This is the prototype of the Cepheid variables which pulsate with a definite rhythm. The variations in δ Cephei were discovered by John Goodricke in 1784. The magnitude varies from 3.6 to 4.3 with a period of 5.366341 days (5 days 8 hours and 48 minutes). The light curve is shown in Figure 1(a). The rise to maximum takes about 1½ days while the fall to minimum requires about four days.

The northern constellation of Cepheus can be observed for several hours following the sunset in September to December. An AAVSO large-scale identification chart is shown in Figure 3. The numbers which appear in the figure are the magnitudes of the comparison stars, multiplied by ten. δ Cephei can be easily monitored visually using the nearby comparison stars, ε Cephei and ζ Cephei.

A few favourable maxima of δ Cephei are in the early parts of the nights on October 25, November 10 and December 23.

μ Cephei

Not far from δ Cephei is the semi-regular variable μ Cephei. The brightness of this star varies between 3.6 and 5.1 mag over the time scales of years. The period is not well defined as in the other members of this class of variables. Fairly extensive observational data are available primarily due to a great series of observations made by J. Plassmann during the years 1881-1935. Later observations are compiled and periodically published by AAVSO. The analysis of the light curves shows that the dominant periodicity is about 900 days while further modulations with periods of 700,1100 and 4500 days are probably present.

A section of the light curve of μ Cephei is shown in Figure 1(d). The identification chart is shown in Figure 3.

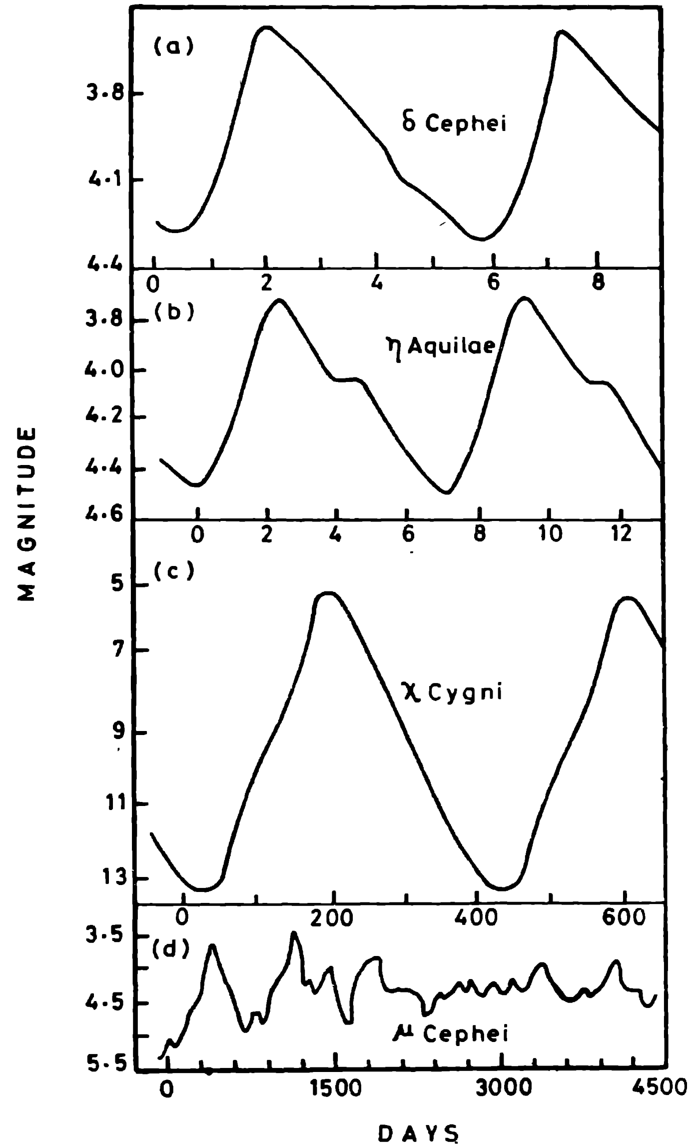

Figure 1. Light curves of (a) δ Cephei, (b) η Aquilae, (c) χ Cygni and (d) μ Cephei. The light curve of χ Cygni is averaged over a few years while that of μ Cephei is a short section around 1974.

η Aquilae

The star η Aquilae is a δ Cephei type variable discovered by Pigott in 1784 soon after Goodricke's discovery of δ Cephei. This star varies in magnitude from 4.5 to 3.7 with a period of 7.17664 days (7 days 4 hours and 14 minutes). The rise requires a little over two days and the fall about five days (Figure 1b). The peculiarity of this Cepheid is that there is a *hump* in the descending branch of the light curve. The star would be at a standstill for nearly nine hours at this point. This phenomenon is shared by Cepheids of periods 7 to 10 days.

An identification chart appears in Figure 2. The variations of this star may be followed by comparing with the nearby stars β Aquilae (3.71 mag), ν Aquilae (4.64 mag) and σ Aquilae (4.64 mag).

The constellation of Aquila will be almost overhead at 7.00 p.m. in the beginning of October and can be observed till December.

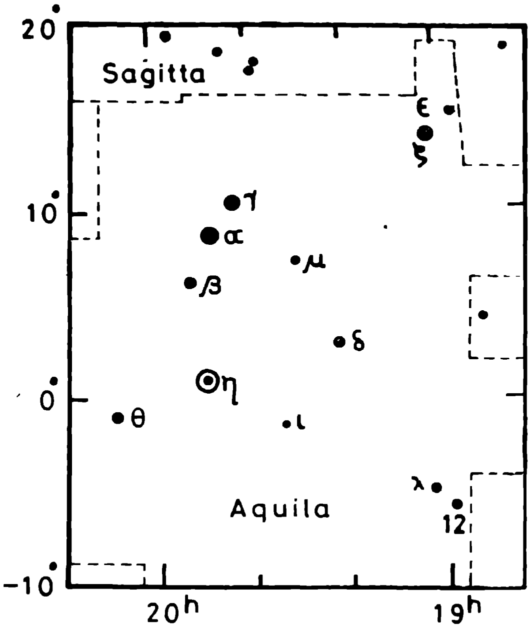

Figure 2. Identification chart for η Aquilae. The star β (3.71 mag) is a useful comparison stars.

χ *Cygni*

This is a long period variable discovered by Gottfried Kirch in 1686. The light variations of long period variables are also due to stellar pulsations as in the case of Cepheids. The periods are however much longer, and the light curve does not repeat itself as faithfully. Mean light curve of χ Cygni is shown in Figure 1(c). While the star generally attains naked-eye visibility at maximum, the brightness at individual maxima varies greatly. At the minimum light it falls below 12th magnitude and cannot easily be identified among the numerous faint stars in the field. A telescope of at least 8-in aperture is required to follow it during the minima. The period of χ Cygni has slowly lengthened from an earlier 402 days to the present 407 days.

χ Cygni is about 30° north of η Aquilae. The AAVSO large-scale chart is reproduced in Figure 4. The star would be in the rising part of its light curve between 1981 September and December, and may attain naked-eye visibility in mid-December.

P Cygni

About ten degrees north-east of χ Cygni is the star P Cygni which showed a spectacular display in the seventeenth century, but is now fairly quiet. It was discovered by Blaeuw in 1600 AD at a magnitude of 3 in a position where no star was visible earlier. P Cygni remained bright for six years and then faded gradually below naked-eye visibility in 1626. It reappeared again in 1655 and brightened to a magnitude of 3.5, at which it remained till 1659. It faded thereafter and was lost to the naked eye in 1662. It rose once again in 1665; after several fluctuations it became steady at about fifth magnitude where it stays since 1715. It will be interesting to watch this star and see whether it erupts again. The nearby stars 28 Cygni (4.98 mag) and 29 Cygni (4.89 mag) are useful comparison stars. P Cygni should normally be comparable in brightness to 29 Cygni.

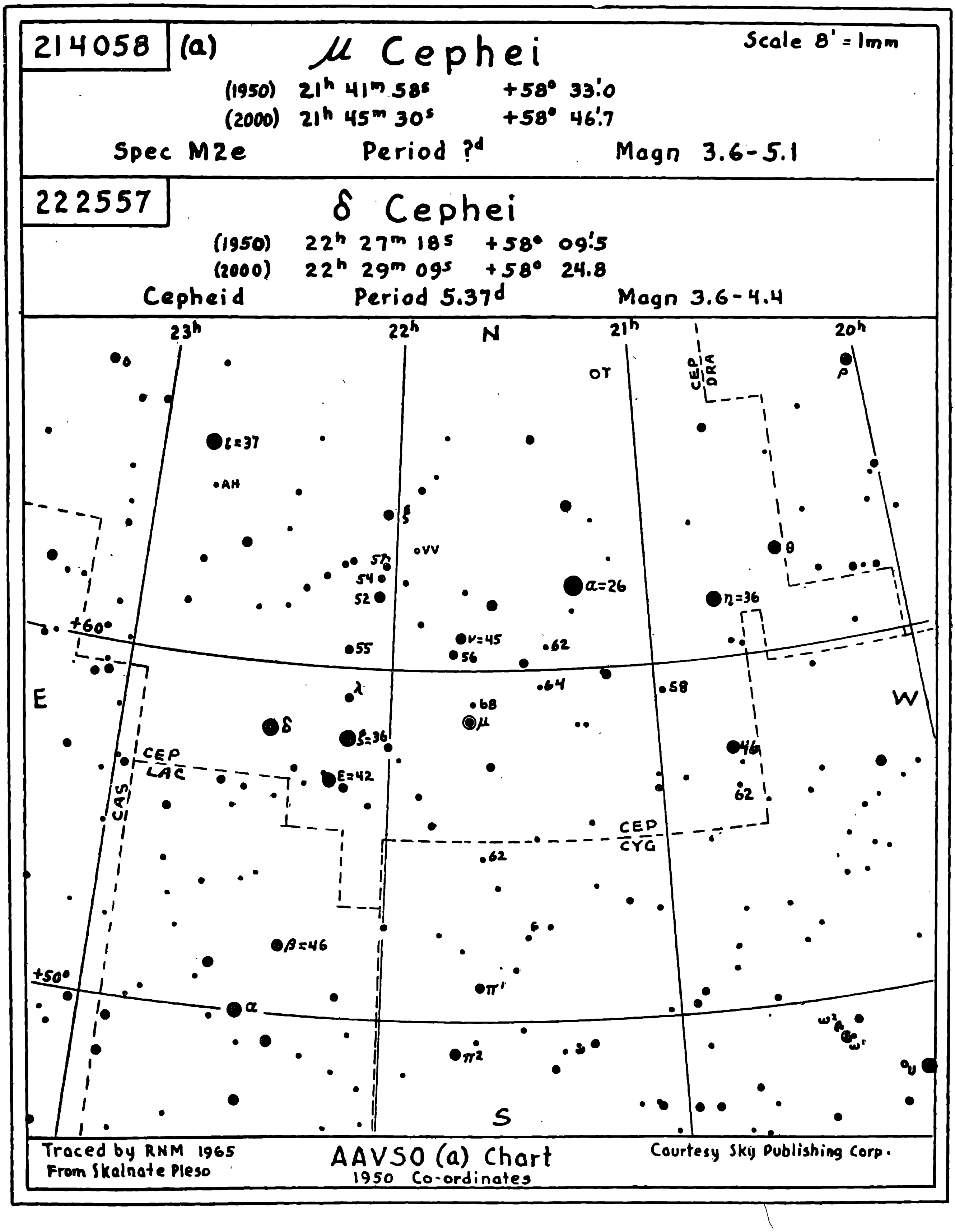

Figure 3. AAVSO large-scale chart for δ Cephei and μ Cephei. The numbered stars are standard comparison stars. The numbers are magnitudes to the nearest tenth of a magnitude with the decimal point omitted. (Courtesy AAVSO)

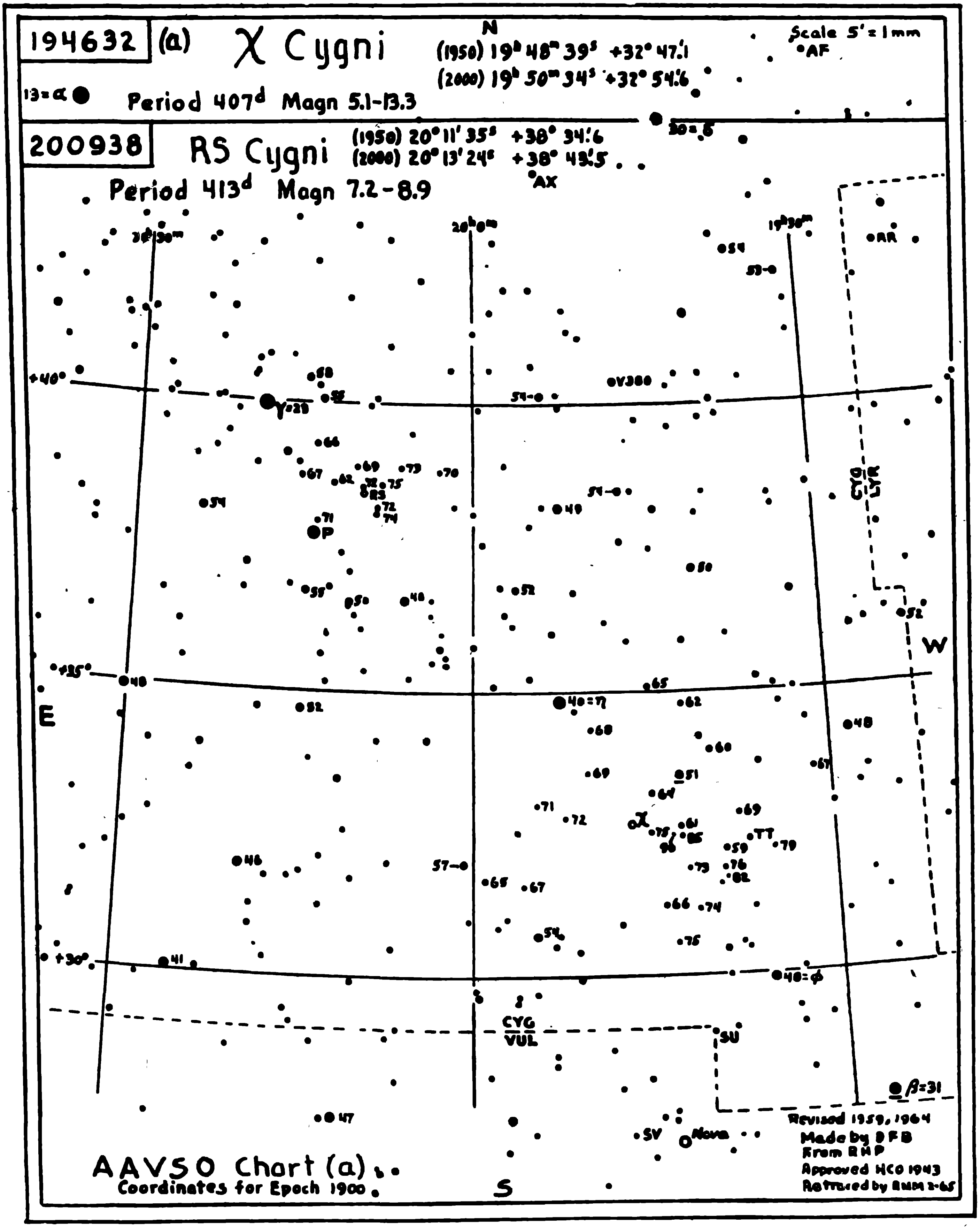

Figure 4. AAVSO large-scale chart for χ Cygni and P Cygni. (Courtesy AAVSO)

Table 2. Lunar occultations in 1981 November and December

Date		Time (UT)			Type	Star	Mag.	SpT	α	1981		δ			Altitude	Percentage illumination
		h	m	s					h	m	s	°	′	″		
November	2	12	16	28	D	30 Sagittarii	6.2	F0	18	49	43.0	−22	11	1	49	26+
		13	51	50	R										33	
		13	37	53	D	BD − 22°4892	6.7	A2	18	51	1.0	−21	56	36	36	
		14	35	10	R										25	
	4	17	40	13	D	BD − 19°5905	7.5	K0	20	42	51.4	−19	24	40	8	46+
	6	14	54	21	D	50 Aquarii	5.9	G5	22	23	28.1	−13	37	22	61	66+
		18	39	4	D	HR 8565	6.2	F0	22	29	2.7	−13	0	33	19	67+
	7	14	46	37	D	ψ^1 Aquarii	4.5	K0	23	14	56.1	−9	11	16	68	76+
		15	16	39	R										67	
	7	15	20	38	D	ψ^3 Aquarii	4.6	B5	23	16	57.3	−9	16	57	67	76+
		16	41	4	R										56	
		19	33	29	D	BD − 9°6183	7.2	K0	23	22	48.6	−8	33	38	19	77+
	8	21	48	34	D	BD − 3°38	7.1	K0	0	20	8.4	−3	0	39	1	87+
	9	15	4	9	D	26 Ceti	6.2	F0	1	2	53.0	−1	16	9	65	92+
	9	17	45	35	D	BD + 1°212	6.7	G5	1	7	3.5	1	53	53	70	93+
		19	43	28	D	33 Ceti	6.2	K0	1	9	37.6	2	20	56	43	93+
		20	23	30	D	BD + 1°223	6.8	F8	1	11	34.8	2	22	32	34	93+
	15	19	29	2	D	δ Geminorum	3.5	F0	7	19	2.1	22	0	57	47	79−
		19	55	12	R										53	
	30	15	00	18	D	BD − 21°5425	7.1	A3	19	31	9.1	−21	33	24	4	13+
December	2	15	58	11	D	30 Capricorni	5.4	B8	21	16	54.8	−18	3	47	14	30+
		16	56	43	R										1	
	3	14	24	51	D	BD − 15°6139	7.1	F5	22	5	12.8	−14	59	10	45	39+
	5	14	17	44	D	HR 9014	6.3	K2	23	47	36.0	−6	28	57	68	60+
	6	20	27	39	D	BD − 1°104	6.8	K0	0	48	59.0	−0	19	26	1	72+
	8	14	45	53	D	HR 725	6.3	K0	2	28	37.4	9	29	5	71	89+
		20	33	27	D	BD + 10°352	6.8	K0	2	38	5.0	10	33	32	26	90+
		21	45	54	D	BD + 9°353	6.7	K0	2	41	1.8	10	28	2	9	91+
		21	59	19	D	HR 797	6.3	A0	2	41	30.6	10	39	52	6	91+
	10	13	35	32	D	BD + 17°732	7.1	F8	4	28	27.8	17	49	24	27	99+
	10	17	55	19	D	BD + 18°661	7.2	G0	4	36	12.0	18	30	23	84	99+
	22	23	32	0	D	γ Librae	4.0	K0	15	34	28.8	−14	43	39	15	10−
	23	0	43	48	R										31	
	29	12	44	18	D	20 Capricorni	6.2	A0p	20	58	32.6	−19	6	27	29	9+
		13	54	3	R											
	31	13	12	24	D	BD − 12°6327	6.8	K2	22	40	26.7	−12	19	38	46	23+
		14	02	16	R										35	

Table 3. Lunar ephemeris and the sidereal time

Date		UT	p_1	$\Delta p_1/\Delta t$	α_1			$\Delta\alpha_1/\Delta t$	δ_1			$\Delta\delta_1/\Delta t$	GST		
		h	arcsec	arcsec h^{-1}	h	m	s	s h^{-1}	°	′	″	arcsec h^{-1}	h	m	s
November	2	14	3261	+1.0	18	53	46.7	128.9	−21	43	25	+15	16	47	01.9
	4	18	3343	+1.8	20	46	14.9	130.0	−19	11	33	+337	20	55	34.4
	6	16	3441	+2.4	22	25	45.0	129.7	−13	10	57	+595	19	03	07.8
	7	15	3496	+2.5	23	15	33.5	130.3	−9	02	40	+697	18	06	54.5
		20	3509	+2.5	23	26	26.0	130.6	−8	03	47	+716	23	07	43.8
	8	22	3571	+2.3	0	23	31.7	133.2	−2	35	53	+790	1	12	00.0
	9	15	3608	+2.0	1	1	37.7	135.9	+1	11	40	+812	18	14	47.6
		20	3618	+2.0	1	12	59.6	136.9	+2	19	26	+814	23	15	36.9
	15	20	3584	−2.1	7	17	8.4	154.8	+21	40	31	−94	23	39	16.2
	30	15	3275	+1.0	19	34	30.0	129.2	−21	33	01	+126	19	37	35.2
December	2	16	3335	+1.6	21	19	28.4	127.4	−17	47	46	+419	20	45	38.3
	3	14	3373	+1.9	22	05	58.5	126.3	−14	52	41	+533	18	49	15.1
	5	14	3473	+2.3	23	46	47.8	126.7	−6	23	22	+724	18	57	08.2
	6	20	3545	+2.3	0	50	55.0	130.3	−0	03	35	+786	1	00	03.9
	8	15	3633	+1.7	2	27	51.2	141.2	+9	19	07	+757	20	09	07.7
	8	22	3645	+1.7	2	44	27.5	143.5	+10	46	17	+736	3	10	16.7
	10	14	3685	+0.2	4	24	34.1	156.6	+17	52	07	+513	19	16	51.0
		18	3686	+0.2	4	35	2.6	157.7	+18	25	15	+481	23	17	30.4
	23	00	3241	−0.3	15	31	0.9	116.8	−14	25	36	−509	6	05	48.2
	29	13	3315	+1.1	21	1	11.1	128.2	−18	50	19	+369	19	31	35.6
	31	14	3679	+1.5	22	44	9.7	123.2	−12	05	38	+608	20	39	38.7

Table 4. Meteor streams active during 1981 November and December

Streams	Epoch	Limits	Max. hourly rate	Radiant			Age of Moon	Local time of transit	Remarks
				α		δ			
				h	m	deg	d	h	
S. Taurids	Nov. 2	Sep. 20 – Dec. 1	15	3	22	+14	5	1	rich in fireballs
N. Taurids	Nov. 13			3	44	+22	16	2	
Cepheids	Nov. 9	Nov. 7–Nov. 11	8	23	30	+63	12	20	needs observations
Leonids	Nov. 17	Nov. 15–Nov. 19	15	10	08	+22	20	6	fast meteors
Phoenicids	Dec. 4	Dec. 4–Dec. 5	5	1	00	−55	8	20	low activity in recent years
Geminids	Dec. 13	Dec. 7–Dec. 15	50	7	32	+32	17	2	very fine shower, rich in fireballs
Ursids	Dec. 22	Dec. 17–Dec. 24	15	14	28	+76	26	8	badly needs observations

2. Lunar occultations

Lunar occultations of bright stars (< 7.5 mag) observable from Kavalur during 1981 November and December are listed in Table 2. The occultations of ψ^1 and ψ^2 Aquarii on the night of November 7 are particularly interesting. These two stars of nearly equal brightness are separated in sky by little over a lunar diameter. The late-night occultation of δ Geminorum on November 15 is at the bright limb of the moon. The eighth magnitude companion of this star, which is easily seen through small telescopes under normal conditions, may not be noticeable at the time of occultation. The occultation of γ Librae, early in the morning of December 23, is also at the bright limb. The crescent moon is, however, not very bright and therefore the occultation is not difficult to observe.

The lunar ephemeris and the Greenwich Sidereal Time are tabulated in Table 3 for selected instants of time. This table will be helpful in the prediction of accurate times of occultations at different geographical locations. The method of calculations has already been described in the June issue of the *Bulletin*.

3. Meteor streams

Some of the meteor streams active during November and December are listed in Table 4. The finest shower in the list is the Geminid shower which reaches its peak activity, unfortunately, near full moon. Geminid shower is well-observed by amateurs and professionals alike. There is no known comet associated with this stream which has the shortest known orbital period (for comets as well as for meteor streams) of less than two years. The activity does not vary appreciably over different years indicating that the matter is evenly distributed along the orbit. From the theoretical calculations on the time needed for dispersal of matter, the age of the stream has been calculated to be 4700 years. The Cepheids (not to be confused with the δ Cephei-type variable stars) and the Ursids need further observations. The latter stream reaches its peak activity near new moon and affords very favourable conditions for observations. The altitude of the radiant is, however, not very high above the northern horizon.